[0019] **FIG. 4***g* illustrates a view of the magnetoresistive sensor undergoing oxygen reactive ion etching; and,

[0020] **FIG. 4***h* illustrates a view of the completed magnetoresistive sensor.

DETAILED DESCRIPTION OF THE INVENTION

[0021] A magnetoresistive sensor having antiparallel coupled biasing tabs according to a preferred embodiment of the invention includes a protective cap layer for each biasing tab. A sensor according to the invention has low parasitic resistance. During manufacture, a sensor having a bias tab structure according to the invention is effectively protected from damage due to ion milling.

[0022] Referring to **FIG. 1, a** magnetic disk drive **100** has at least one rotatable magnetic disk **102** supported by a spindle **104** and rotated by a motor (not shown). There is at least one slider **106** with an attached recording head **108** positioned over the disk **102** surface while reading and writing. The recording head **108** includes a write element for writing data onto the disk **102**. The recording head also includes a magnetic spin valve sensor according to the present invention (shown in detail below) used as a read element for reading data from the disk. The slider **106** is attached to a suspension **110** and the suspension **110** is attached to an actuator **112**. The actuator **112** is pivotally attached **114** to the housing **116** of the disk drive **100** and is pivoted by a voice coil motor **118**. As the disk is rotating, the actuator **112** positions the slider **106** and suspension **110** along a radial arcuate path **120** over the disk **102** surface to access the data track of interest.

[0023] Again referring to **FIG. 1**, during operation of the disk drive **100**, the motion of the rotating disk **102** relative to the slider **106** generates an air bearing between the slider **106** and the disk **102** surface which exerts an upward force on the slider **106**. This upward force is balanced by a spring force from the suspension **110** urging the slider **106** toward the surface of the disk **102**. Alternatively, the slider **106** may be in either partial or continuous contact with the disk **102** surface during operation.

[0024] **FIG. 2** illustrates a more detailed view of a slider **200**. The recording head **218** is preferably constructed on the trailing surface **206** of the slider **200**. **FIG. 2** illustrates the upper pole **208** and the turns **210** of the coil **214** of the write element of the recording head **218**. The read element includes a read sensor **204** disposed between two magnetic shields **220** is formed between the slider body **202** and the write element. The electrical connection pads **212** which allow connection with the write element and read element are illustrated.

[0025] **FIG. 3***a* illustrates a partially completed magnetoresistive sensor **300** according to the prior art. The pinned layer **302** may be a simple layer of ferromagnetic material. Alternatively, the pinned layer **302** may be an assembly of antiparallel coupled ferromagnetic layers. The pinned layer **302** may be formed over an antiferromagnetic layer (not shown). Alternatively, a antiferromagnetic layer may not be necessary if the pinned layer **302** is self-pinned. A nonmagnetic conducting layer **304** is formed over the pinned layer **302**. A ferromagnetic free layer **306** is formed over the nonmagnetic conducting layer **304**. A thin nonmagnetic layer **308**, usually ruthenium, is formed over the free layer **306** and promotes antiparallel coupling with the ferromagnetic bias layer **310** which is formed over the thin nonmagnetic layer **308**. A cap layer **312**, usually of tantalum, is formed over the bias layer **310**. The structure **300** as illustrated in **FIG. 3***a* is now removed from vacuum and annealed at elevated temperature.

[0026] **FIG. 3***b* illustrates a formation of oxidized material **314** in the cap layer **312** which resulted from the annealing operation. The oxide layer **314** must be removed with ion milling **316** to insure good electrical connection with subsequently formed lead structures (not shown). This ion milling operation **316** must be relatively aggressive to adequately remove the oxide layer **314** thus risking damage to the bias layer **310** and necessitating a thicker cap layer **312**.

[0027] **FIG. 4***a* illustrates a view of a partially completed magnetoresistive sensor **400** according to the present invention. The sensor **400** includes a pinned layer **402** which may be a simple layer of ferromagnetic material. Alternatively, the pinned layer **402** may be an assembly of antiparallel coupled ferromagnetic layers. The pinned layer **402** may be formed over an antiferromagnetic layer (not shown). Alternatively, an antiferromagnetic layer may not be necessary if the pinned layer **402** is self-pinned. A nonmagnetic conducting layer **404**, typically of copper, is formed over the pinned layer **402**. A ferromagnetic free layer **406** is formed over the nonmagnetic conducting layer **404**. The free layer **406** may be a single layer of ferromagnetic alloy or alternatively multiple layers of ferromagnetic alloys. Appropriate ferromagnetic alloys are typically formed from binary or tertiary combinations of iron, nickel, and cobalt. A thin nonmagnetic coupling layer **408**, usually ruthenium, is formed over the free layer **406**. This thin nonmagnetic coupling layer **408** promotes antiparallel coupling between a ferromagnetic bias layer **410** formed over the thin nonmagnetic layer **408** and the underlying free layer **404**. The magnetic moment of the bias layer **410** should ordinarily be somewhat greater than the magnetic moment of the free layer **406**. A cap layer **412**, usually of tantalum, is formed over the bias layer **410**. Importantly, a protective cap layer **414** is formed over the cap layer **412**. The protective cap layer **414** may be formed from rhodium (Rh), gold (Au), ruthenium (Ru), or other material which protects the cap layer against oxidation and is not readily oxidized itself. The protective cap layer **414** is effective in a thickness range of about 10 to 30 Angstroms. A protective cap layer thicker than 30 Angstroms is also likely to be effective but could add undesirable thickness to the sensor stack. The magnetoresistive sensor **400** as illustrated in **FIG. 4***a* is now removed from vacuum and annealed at elevated temperature.

[0028] **FIG. 4***b* illustrates a view of the magnetoresistive sensor after annealing and after the formation of a photoresist liftoff structure **450**. The cap layer **412** was protected from oxidation during annealing by the protective cap layer **414**. The material chosen for the protective cap layer **414** is not readily oxidized during annealing. An advantage of the present invention is that the cap layer can be relatively thin with a thickness range of about 30 to 50 Angstroms. In contrast, the thickness of the cap layer of the prior art (**312** in **FIGS. 3***a* and **3***b*) was typically greater than about 80 Angstroms.